AF

Name _____ Class _____ Date _____

Molar Volume of a Gas

Experiment 14

Process Objectives

- To measure the volume of H_2 collected in the experiment.
- To formulate a balanced equation for the experiment.

Learning Objectives

- To determine the volume of one mole of a gas at standard temperature and pressure.
- To discover the difference that water vapor pressure will make in the total pressure of a gas collected over water.

Introduction

When magnesium metal reacts with hydrochloric acid, hydrogen gas is produced. The volume of this gas can be measured by using a eudiometer. Knowing the number of moles of magnesium used, we can calculate the volume of hydrogen produced per mole of magnesium consumed. The balanced equation for this reaction allows us to determine the volume that one mole of gas occupies at a specified temperature and pressure.

Magnesium is the least dense structural metal. Because of its lightness it is often alloyed with aluminum and used to make custom-designed racing car wheels, called MAG wheels. Both magnesium and aluminum are very reactive with acids, such as with the hydrochloric acid used in this experiment. This explains why manufacturers of these very expensive wheels warn consumers that the use of any acid cleaning product will affect the surface and void the warranty.

Refer to Chapter 12, Section 12.1 and 12.3 for additional information on gas volumes.

Safety

Take the necessary precautions before beginning this experiment. Wear safety goggles, apron, and gloves. Read all safety cautions in your procedures and discuss them with your teacher. It is important to use good safety techniques while conducting experiments. See pages 8 through 11.

Apparatus

beakers, 400 mL, 50 mL
thermometer
hydrometer jar or 1000 mL graduated cylinder
ring stand
buret clamp
centimeter rule
rubber stopper (one-hole, #00)
eudiometer, 50 mL

Materials

magnesium ribbon, untarnished
hydrochloric acid, 6 *M*
thread

Recording Your Observations

After completing each step of the procedures, record your observations in the Data Table.

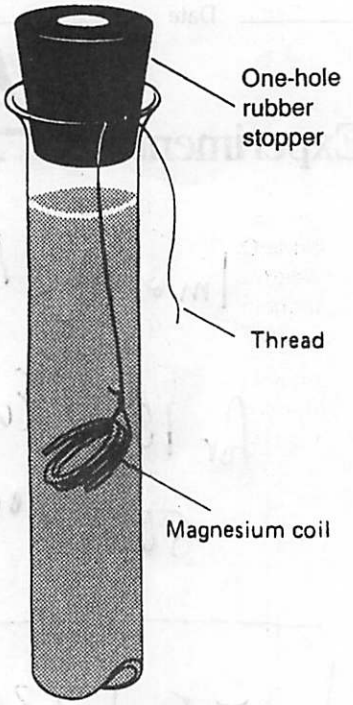

Figure 14-1

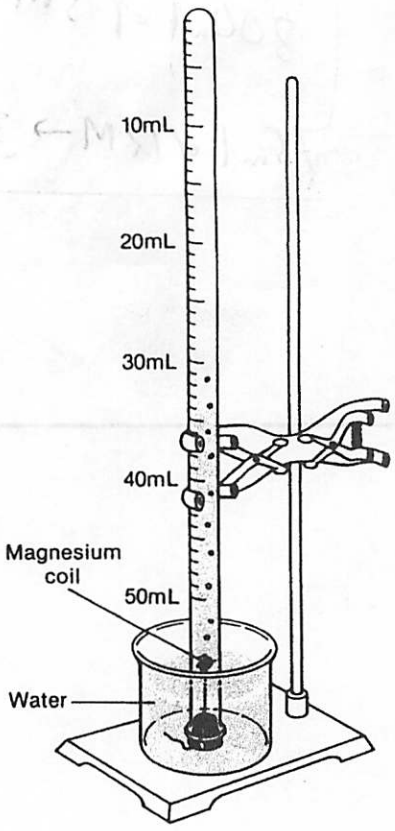

Figure 14-2

Procedures

1. Fill a 400 mL beaker two-thirds full of water. If possible, use water that has adjusted to room temperature. Obtain a piece of magnesium ribbon from your instructor. Measure the length of magnesium ribbon to the nearest 0.1 cm. (Note: If your piece of ribbon exceeds 4.5 cm, then return it for a smaller one.) Record the length of the ribbon in your Data Table. Also record the mass of one meter of this ribbon. You can obtain this mass from your teacher.
2. Roll the length of magnesium ribbon into a loose coil. Tie it with one end of a piece of thread, approximately 25 cm in length, in such a manner that all the loops of the coil are tied together.
3. This next procedure requires the use of 6 *M* hydrochloric acid. You may want to practice Procedures 3 to 6 by using water in place of the acid. When you have mastered the technique using water, proceed to use the acid.

CAUTION Hydrochloric acid is caustic and corrosive. Avoid contact with skin and eyes. Avoid breathing the vapor. Make certain that you are wearing safety goggles, apron, and gloves when working with the acid. If any acid should splash on you, immediately flush the area with water and then report the incident to your teacher. If you should spill any on the counter top or floor, ask your teacher for the appropriate spill package to be used in the clean-up.

Carefully pour approximately 10 mL of 6 *M* hydrochloric acid into a 50-mL beaker. Then pour the 10 mL of 6 *M* hydrochloric acid into the gas measuring tube or eudiometer.

4. While holding the eudiometer in a slightly tipped position, very slowly pour water from the 400 mL beaker into the eudiometer, being careful to layer the water over the acid so that they do not mix. Add enough water to fill the eudiometer completely.
5. Lower the magnesium coil into the water in the eudiometer tube to a depth of about 5 cm. Insert the rubber stopper into the open end of the eudiometer to hold the thread in position. See Figure 14-1. The one-hole stopper should displace some water from the tube. This ensures that no air is left inside the tube.
6. Cover the hole of the stopper with your finger, and invert the eudiometer in the 400 mL beaker of water. Clamp the eudiometer tube into position on the ring stand, as shown in Figure 14-2. The acid flows down the tube (why?) and reacts with the magnesium. Is the acid now more concentrated or more dilute? Describe your observations.

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7. When the magnesium has disappeared entirely and the reaction has stopped, cover the stopper hole with a finger and carefully transfer the eudiometer tube to a 1000 mL graduated cylinder or other tall vessel that has been filled with water. Adjust the level of the eudiometer tube in the water so that the levels of the liquids inside the eudiometer and the cylinder are the same. See Figure 14-3. Read as accurately as possible the volume of hydrogen liberated.
8. Record the room temperature and pressure.
9. Obtain the vapor pressure of the water at the observed temperature from the table "Water-Vapor Pressure" on page 223 of the lab manual. Record the vapor pressure in the Data Table. Wash your hands.

Strategy for Measuring
In this experiment the pressure of the gas is made equal to atmospheric pressure by equalizing the water levels inside and outside the collection tube.

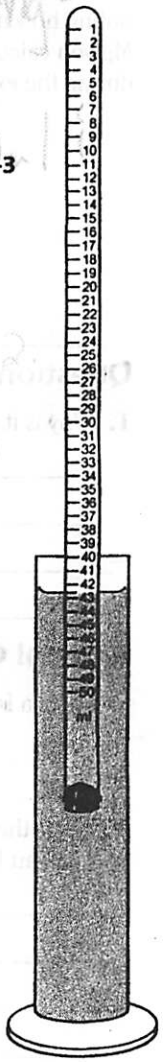

Figure 14-3

Data Table		
Length of Mg used		cm
Mass per meter of Mg		g/m
Volume of H_2 collected (at laboratory conditions)		mL
Temperature of H_2 collected		°C
Barometer reading		mm Hg
Vapor pressure of water at observed temperature		mm Hg

Calculations

Show your computations. Place your answers in the Calculations Table.

1. Determine the mass of your magnesium ribbon.

2. Calculate the number of moles of magnesium consumed.

3. Since the hydrogen was collected over water, two gases were actually present: hydrogen and water vapor. Calculate the partial pressure of the hydrogen gas collected. (Hint: The total atmospheric pressure equals the sum of the two partial pressures.)

4. Calculate the volume (V_1) of dry hydrogen gas at standard atmospheric pressure (P_1),

$$V_1 = \frac{V_2 P_2}{P_1}$$

5. Calculate the volume (V_1) of dry hydrogen gas at standard temperature (T_1),

$$V_1 = \frac{V_2 T_1}{T_2}$$

6. Calculate the volume of dry hydrogen gas that would be produced by one mole of magnesium at standard temperature and pressure.

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Strategy for Formulating
The equation can be derived by noting how many moles of H_2 and Mg you calculated as being formed during the experiment.

Calculations Table		
Mass of Mg used		g
Moles of Mg consumed		mol
Pressure of H_2 collected		mm
Volume of dry H_2 at SP		mL
Volume of dry H_2 at STP		mL
Volume of dry H_2 per mole Mg . . .		mL/mol
Volume of 1 mole H_2 at STP		mL/mol

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Question

1. Why is it necessary to make a water-vapor pressure correction of the barometer reading in this experiment?

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General Conclusions

1. Write a balanced equation for magnesium reacting with HCl forming H_2 gas and $MgCl_2$.

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2. From the balanced equation above, determine the volume of hydrogen gas at standard temperature and pressure that can be produced from 3 moles of magnesium reacting with acid.

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3. Since the 1930's, aluminum/magnesium alloys have been used in the manufacture of pots and pans. An unanswered question is whether the small addition of these metals to our food supply is beneficial, harmful, or of no consequence. What are some examples of foods that will react with aluminum/magnesium pans?

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